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A NOVEL PV ARRAY WITH MPPT OF SWITCHED CAPACITOR INVERTER CONNECTED GRID

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ABSTRACT

A multilevel inverter with a limited number of switching devices is proposed. That (SCI) switched capacitor inverter consists Marx inverter structure and H-bridge. The inverter which outputs of multilevel voltage by switching the DC voltage sources in series and in parallel. In this proposed inverter PV array and MPPT are combined from that the total harmonic distortion are reduced of the output waveforms. Most residential households will use a grid-connected PV system. The PV array inverter with grid THD of the output waveform of the inverter is reduced compared to SC inverter the simulation results has been done in MATLAB/SIMULINK are shown.

KEYWORDS: Multilevel Inverter, Switched Capacitor Inverter, PV Array, MPPT

INTRODUCTION

The last few years Electric Vehicles (EVs), Hybrid Electric Vehicles (HEV) are researching all over the world due to several advantages like to increased fuel efficiency, lower emission and better vehicle performance. These vehicle have to use the large electric drivers to require advanced power electronic inverters to meet the high power demands, one of the drawback in these studies when the switching devices are operated at the high voltages, the switching frequency is restricted. The multilevel inverter has gained good attention in recent years due to its advantages in high power with low harmonics applications.

To overcome these problems in multilevel inverters, because their individual devices have a high lower voltage per switching and they operate at high efficiencies because it has a lower frequency than PWM controlled inverters. The inverters can be used in HEV and EV. Several multilevel inverter topologies have been developed like flying capacitor. A charge pump outputs a large voltage than the input voltage with the switched capacitors. When the multiple capacitors and the input voltage sources are connected in parallel, the capacitors are charged. When the multiple capacitors and input voltages are connected in series, the capacitors are discharged. The charge pump outputs the sum of the voltages of the capacitor and the input voltage sources.

Our proposed inverter design does not have any inductors can be smaller than a conventional Bi-stage unit it consists of a boost converter and an inverter bridge, which makes the system has a large however, a charge pump has many switching devices it makes a system is more complicated. An SC inverter is similar to a charge pump in the topology. In this SC inverter the output voltage is larger than the input voltage in similar way to the charge pump. Similarly in SC inverter also have many switching devices, which make the system as complicated. The other technique, a matrix inverter has less switching devices compare to the SC inverter, was proposed.

DESIGN TOPOLOGY

Circuit of SC Inverter is shown below of figure 1

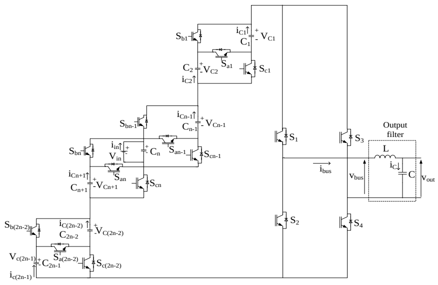
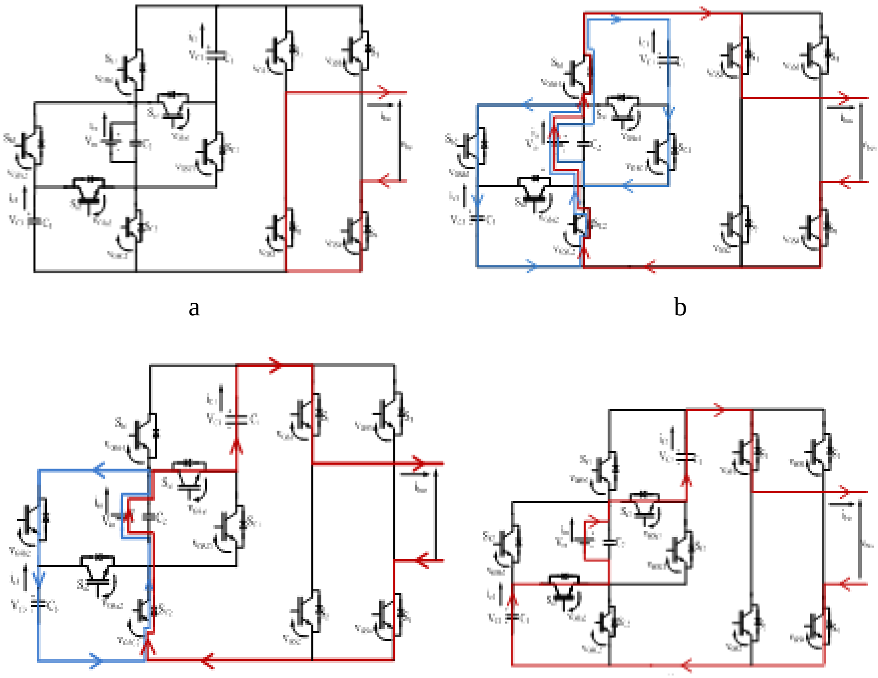


Figure 1: Circuit Topology of the Switched Capacitor Inverter Using Series/Parallel Conversion

Modes of circuit is given below.



a b

c d

Figure 2: Current Flow of the Proposed Inverter (N = 2) on Each State, (a) The Current I $_{bus}$ Does Not Flow in the Capacitors C_k, (b) All Capacitors are Connected In parallel, (c) The Capacitor C_1 is Connected in Series and the Capacitor C_3 is Connected in Parallel, and (d) All Capacitors are Connected in Series

The topology of the proposed circuit inverter, have S_{ak}, S_{bk}, S_{ck} (k=1, 2, 3, , 2n-2) are the switching devices which ,makes the capacitors C_k(k=1,2, …, 2n-1) in series and in parallel. The designed S_1 to S_4 switches are in the inverter bridge.

The V $_{in}$ is input voltage source. In this a low pass filter is composed of an inductor L and a capacitor C. Many modulation methods to drive a multilevel inverter: The space vector modulations the multicarrier pulse width modulation, the hybrid modulation are the selective harmonic elimination and the nearest level control, in this the multicarrier PWM method is applied to proposed inverter. In this proposed different methods are applied, method2 shows the current flow in the proposed inverter (n=2). In method3 shows the modulation method of the proposed inverter (n=2). When the time t satisfies $0 \leq t < t1$, and the switches S_1 and S_2 are driven by the gate source voltage of V_{GS1} and V_{GS2}, respectively. While the switches S1and S2 are switched alternately, the other switches are maintained ON or OFF states as shown. The bus voltages V_{bus} takes 0 or V_{in}. when the time t satisfies $t_1 \leq t < t_2$ in figure 2, the switches S_{a1}, S_{b1}, and S_{c1} are driven by the gate source voltages V_{GSa1}, V_{GSb1}, and V_{GSc1}, respectively. While the switches S_{a1}, S_{b1}, and S_{c1} are switched alternately, the other switches are maintained ON or OFF states as shown in figure 2. Therefore the proposed inverter can output the voltage V_{bus} while the capacitor C_1 is charged. The bus voltage V_{bus} is

$$V_{bus}=V_{in}+V_{C1} \quad (1)$$

Where Vc1 is the voltage of the capacitor C_1.

METHODOLOGY OF THE PROPOSED INVERTER

The proposed inverter outputs V_{in} or V_{in} + V_{c1} alternately in this term. When the time t satisfies $t_2 \leq t < t_3$, and the switches S_{a2}, S_{b2} and S_{c2} are driven by the gate source voltages VGSa2, V_{GSb2}, and V_{GSc2} respectively. The switches S_{a2}, S_{b2} and S_{c2} are switches alternately, the other switches are maintained ON or OFF states as shown in figure 3. The capacitor C_3 is charged by the current $-iC_3$ as during the state.

Modulation method of the proposed inverter (n=2).

$$v_{bus} = V_{in}+Vc_1+V_{c3} \quad (2)$$

Where V_{c3} is the voltage of the capacitor C_3. Therefore the proposed inverter outputs V_{in} + V_{C1} or V_{in} + V_{C1}+ V_{c3} alternately in this term. After $t=t_3$, the four states repeated by turns. The Table I shows the list of the on state switches when the proposed inverter is driven by the modulation method as shown in figure 2. The ideal bus voltage V_{bus} in Table 1 means the bus voltage on each state when VC1=VC3=V_{in} is assumed. The SC inverter, the proposed inverter has full bridge which is connected to the high voltage.

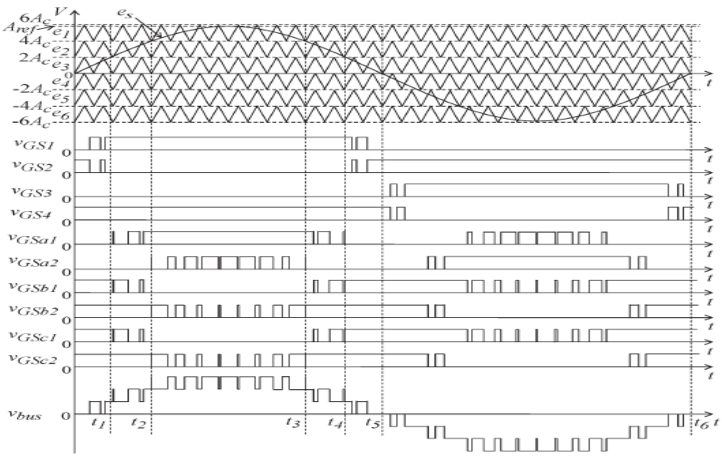


Figure 3: Modulation Method of the Proposed Inverter

Table 1: List of on State Switches on Each State

Relationship Between e_s and e_k	On-state switches	Ideal bus voltage v_{bus}
$e_s > e_1$	S_1, S_4, S_{a1}, S_{a2}	$3v_{in}$
$e_1 \geq e_s > e_2$	$S_1, S_4, S_{a1}, S_{b2}, S_{c2}$	$2v_{in}$
$e_2 \geq e_s > e_3$	$S_1, S_4, S_{b1}, S_{c1}, S_{b2}, S_{c2}$	v_{in}
$e_3 \geq e_s > e_4$	$S_2, S_4, S_{b1}, S_{c1}, S_{b2}, S_{c2}$	0
$e_4 \geq e_s > e_5$	$S_2, S_3, S_{b1}, S_{c1}, S_{b2}, S_{c2}$	$-v_{in}$
$e_5 \geq e_s > e_6$	$S_2, S_3, S_{b1}, S_{c1}, S_{a2}$	$-2v_{in}$
$e_6 > e_s$	S_2, S_3, S_{a1}, S_{a2}	$-3v_{in}$

The device stress of the switches *S*1 to *S*4 in the full bridge is higher than the other switches as the conventional SC inverter. The proposed inverter (n = 2) outputs a 7-level voltage by repeating the four states. Because the driving waveform V_{GSa1} and V_{GSa2} change alternately as shown in Figure 2, the capacitors C_1 and C_2 are equally discharged. Assuming that the number of the capacitors is $2n - 1$, the proposed inverter can outputs $4n - 1$ levels voltage waveform.

The modulation index *M* is defined as the following equation because the amplitude of the output voltage waveform is inversely proportional to the double amplitude of the carrier waveform.

$$M=A_{ref}/2A_{c.} \tag{3}$$

Here A_{ref} is the amplitude of the carrier waveform. The proposed inverter requires 10 switching devices for the 7-level and 16 switching devices for the 11-level. The other hand the conventional SC inverter requires 20 switching devices for the 7-level and 28 switching devices for the 11 level. The conventional cascaded H-bridge inverter requires 12 switching devices for the 7-level switching and 20 switching devices for the 11-level , when all the dc voltage sources takes the same voltage. Therefore the proposed inverter has less number of switching devices than the conventional multilevel inverters.

MODELING AND SIMULATION RESULTS

The simulation was performed under the two cases:

- Proposed single phase serial/parallel topology.
- SC inverter with PV array and grid.

Single Phase Serial/Parallel Topology

The simulation circuit of single phase series/parallel given below

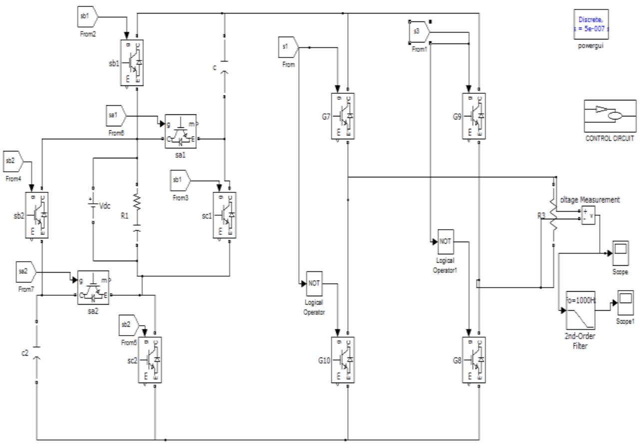


Figure 4: The Simulation Model SC Inverter for Multicarrier PWM Method

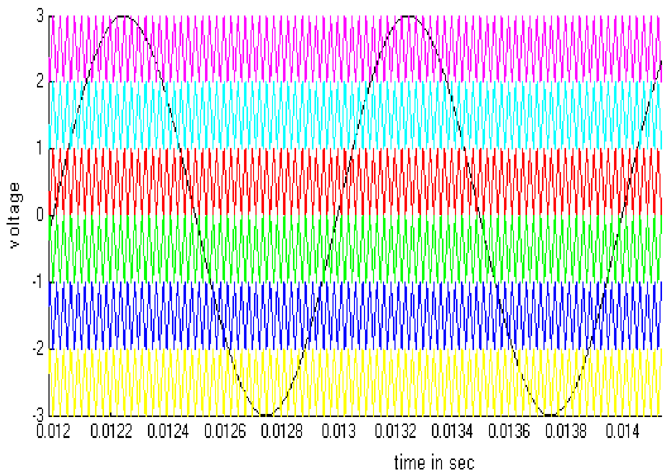


Figure 5: Inputs of the SC Inverter Circuit

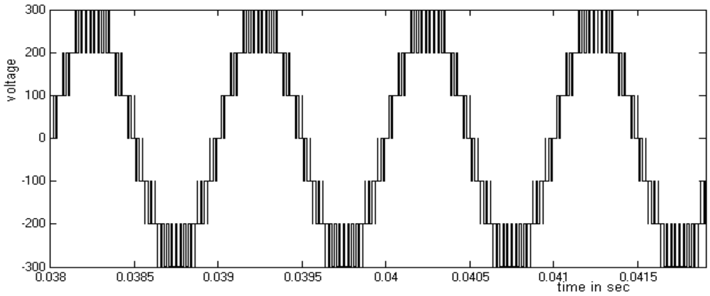


Figure 6: Shows Single Phase Seven Level Output Voltage without Filter of the Proposed Series/Parallel Converter

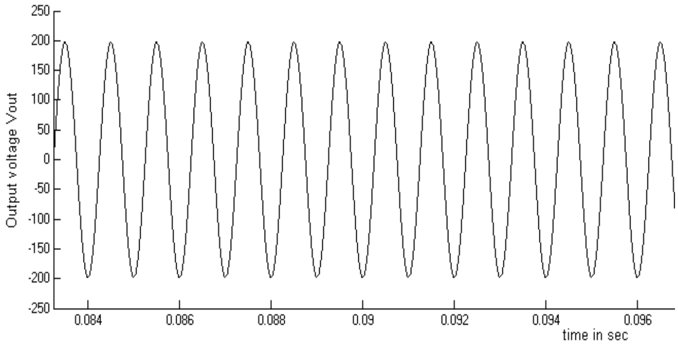


Figure 7: Shows a Single Phase Output Voltage with Filter of Proposed Series/ Parallel Converter, by Using Filter We Get Fully Sinusoidal Nature of the Voltage

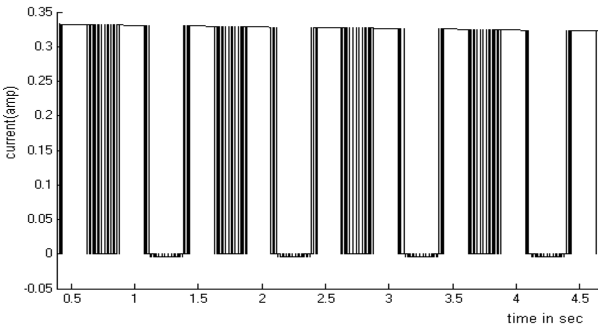


Figure 8: Shows Current Waveforms of Capacitor

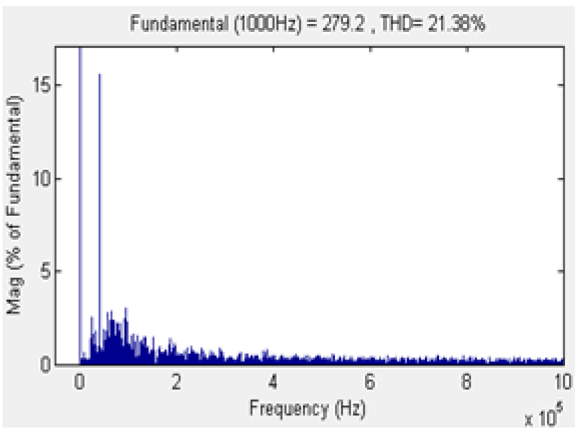


Figure 9: Shows Proposed Inverter of Normalized with the Fundamental Component

SC INVERTER WITH PV ARRAY AND GRID SIMULATION RESULTS

PV arrays use an inverter to convert the DC power into alternating current that can power the motors, loads, lights

etc. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current. In this PV array inverter with grid are connected in 50 series modules and 4 parallel modules. By connecting more series modules high voltage was obtained. In this PV array inverter the high will be obtained than the input voltage.

Maximum Power Point Tracking

- Maximum power point tracking (MPPT) based solar charger/charge controller plays a vital role in increasing the overall efficiency of solar PV based system.
- Implementing a MPPT algorithm in charge controller of a solar PV system is necessary because the current-voltage characteristics of solar PV arrays is non-linear where at a particular point the power output is maximum. So to extract the maximum power from the solar PV system, implementation of MPPT algorithm is must.
- Maximum Power Point tracking can be done in a few different methodology; they are
- Perturb and Observe (P&O) Method,
- Incremental Conductance Method (INC) and
- Constant Voltage Method.

Perturb and Observe Method

In this method, the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments n that direction, further adjustments in that direction are tried until power no longer increases. This is called **Perturb and Observe method**.

It is referred as a hill climbing method, because it depends on the rise of the curve of point against voltage below the maximum power point, and the fall above that point.

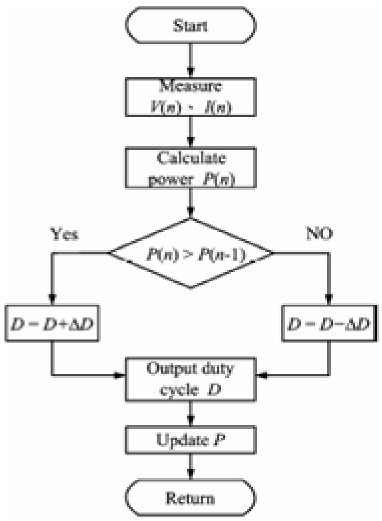


Figure 10: Flow Chart of P&O Method

- The advantage of the P&O method is that it is easy to implement.

Grid-Tie Inverters

- Most residential households will use a grid-connected PV system. It is used to complement the generated solar power with grid power.
- On the DC side, maximum power point tracking (MPPT) optimizes the power output by varying the closed loop system voltage. On the AC side, these inverters ensure that the sinusoidal output is synchronized to the grid frequency.

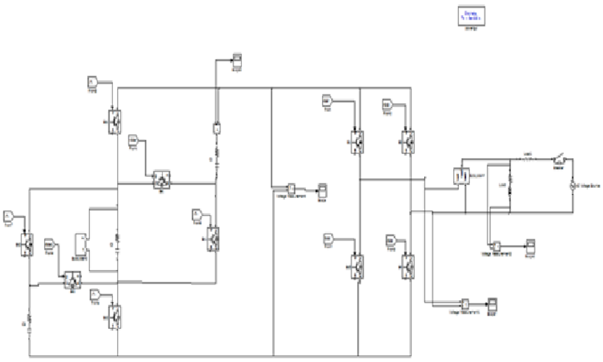


Figure 11: SC Inverter with PV Array and Grid

In this PV array module are connected with 50 series modules and 4 parallel modules. For high voltage high series modules are connected

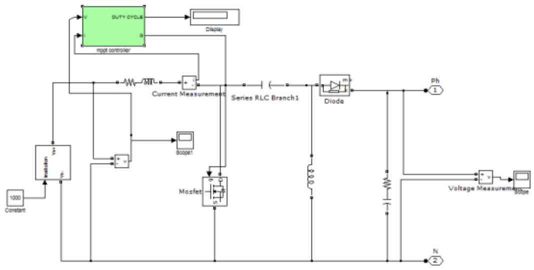


Figure 12: Block of PV Array

To draw the Maximum power the MPPT block parameter was connected to PV array as shown in figure

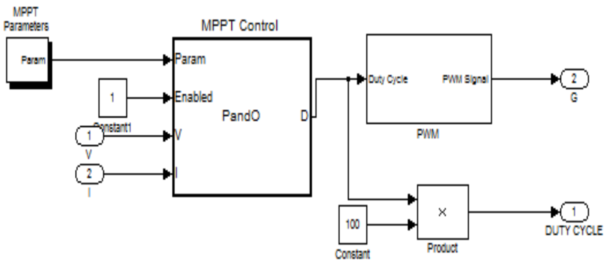


Figure 13: Block of MPPT Control

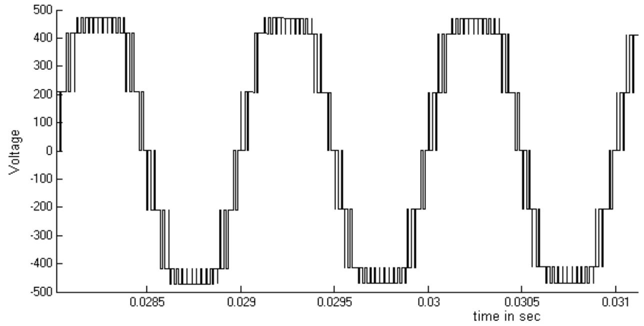


Figure 14: Output Voltage without Filter of the Proposed SC Inverter with PV Array without Filter

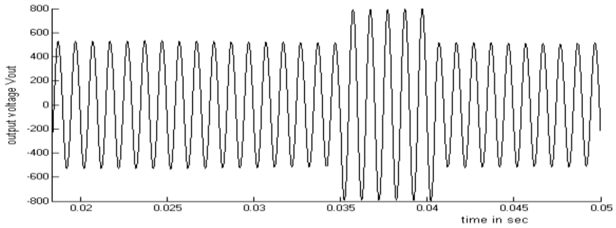


Figure 15: Output Voltage

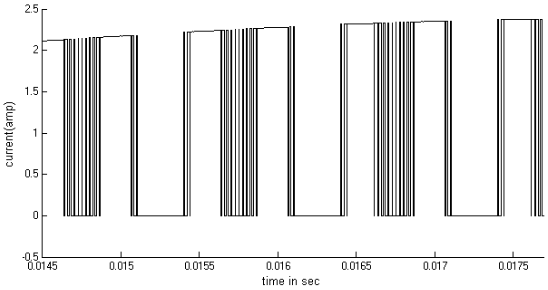


Figure 16: Shows Current Waveforms of Capacitor

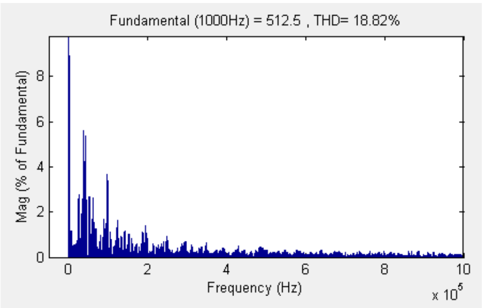


Figure 17: Shows PV Array Inverter of Normalized with the Fundamental Component

CONCLUSIONS

In this paper a novel single phase SC inverter and PV array with SC inverters was proposed. The proposed inverter was confirmed conformed by the simulation results with a resistive load and inductive load. The proposed inverter outputs a large voltage than the input voltage of the switching capacitor in series and in parallel. The inverter can operate with a selected inductive load. The design of this inverter is simpler than the conventional switched capacitor inverters. The proposed PV array SC inverter gives THD of the output waveform of the inverter can be reduced compare to the switched capacitor inverter.

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